Historic, archived document

Do not assume content reflects current scientific knowledge, policies, or practices.

U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF PLANT INDUSTRY—BULLETIN NO. 177.

B. T. GALLOWAY, *Chief of Bureau.*

A PROTECTED STOCK RANGE IN ARIZONA.

LIBRARY
RECEIVED
★ APR 21 1910 ★
U. S. Department of Agriculture

BY

DAVID GRIFFITHS,

AGRICULTURIST, OFFICE OF FARM MANAGEMENT.

ISSUED APRIL 19, 1910.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1910.

BULLETINS OF THE BUREAU OF PLANT INDUSTRY.

The scientific and technical publications of the Bureau of Plant Industry, which was organized July 1, 1901, are issued in a single series of bulletins, a list of which follows.

Attention is directed to the fact that the publications in this series are not for general distribution. The Superintendent of Documents, Government Printing Office, Washington, D. C., is authorized by law to sell them at cost, and to him all applications for these bulletins should be made, accompanied by a postal money order for the required amount or by cash. Numbers omitted from this list can not be furnished.

No. 2. Spermatogenesis and Fecundation of Zamia. 1901. Price, 20 cents.
3. Macaroni Wheats. 1901. Price, 20 cents.
4. Range Improvement in Arizona. 1901. Price, 10 cents.
8. A Collection of Fungi Prepared for Distribution. 1902. Price, 10 cents.
9. The North American Species of Spartina. 1902. Price, 10 cents.
10. Records of Seed Distribution, etc. 1902. Price, 10 cents.
11. Johnson Grass. 1902. Price, 10 cents.
13. Range Improvement in Central Texas. 1902. Price, 10 cents.
14. The Decay of Timber and Methods of Preventing It. 1902. Price, 55 cents.
15. Forage Conditions on Northern Border of Great Basin. 1902. Price, 15 cents.
17. Some Diseases of the Cowpea. 1902. Price, 10 cents.
20. Manufacture of Semolina and Macaroni. 1902. Price, 15 cents.
22. Injurious Effects of Premature Pollination. 1902. Price, 10 cents.
23. Berseem: The Great Forage and Soiling Crop of Nile Valley. 1902. Price, 15 cents.
24. Unfermented Grape Must. 1902. Price, 10 cents.
25. Miscellaneous Papers. 1903. Price, 15 cents.
27. Letters on Agriculture in the West Indies, Spain, and the Orient. 1902. Price, 15 cents.
29. The Effect of Black-Rot on Turnips. 1903. Price, 15 cents.
31. Cultivated Forage Crops of the Northwestern States. 1902. Price, 10 cents.
32. A Disease of the White Ash. 1903. Price, 10 cents.
33. North American Species of Leptochloa. 1903. Price, 15 cents.
35. Recent Foreign Explorations. 1903. Price, 15 cents.
36. The "Bluing" of the Western Yellow Pine, etc. 1903. Price, 30 cents.
37. Formation of Spores in Sporangia of Rhizopus Nigricans, etc. 1903. Price, 15 cents.
38. Forage Conditions in Eastern Washington, etc. 1903. Price, 15 cents.
39. The Propagation of the Easter Lily from Seed. 1903. Price, 10 cents.
41. The Commercial Grading of Corn. 1903. Price, 10 cents.
42. Three New Plant Introductions from Japan. 1903. Price, 10 cents.
47. The Description of Wheat Varieties. 1903. Price, 10 cents.
48. The Apple in Cold Storage. 1903. Price, 15 cents.
49. The Culture of the Central American Rubber Tree. 1903. Price, 25 cents.
50. Wild Rice: Its Uses and Propagation. 1903. Price, 10 cents.
51. Miscellaneous Papers. 1905. Price, 5 cents.
54. Persian Gulf Dates. 1903. Price, 10 cents.
59. Pasture, Meadow, and Forage Crops in Nebraska. 1904. Price, 10 cents.
60. A Soft Rot of the Calla Lily. 1904. Price, 10 cents.
61. The Avocado in Florida. 1904. Price, 5 cents.
62. Notes on Egyptian Agriculture. 1904. Price, 10 cents.
67. Range Investigations in Arizona. 1904. Price, 15 cents.
68. North American Species of Agrostis. 1905. Price, 10 cents.
69. American Varieties of Lettuce. 1904. Price, 15 cents.
70. The Commercial Status of Durum Wheat. 1904. Price, 10 cents.
71. Soil Inoculation for Legumes. 1905. Price, 15 cents.
72. Miscellaneous Papers. 1905. Price, 5 cents.
73. The Development of Single-Germ Beet Seed. 1905. Price, 10 cents.
74. Prickly Pear and Other Cacti as Food for Stock. 1905. Price, 5 cents.
75. Range Management in the State of Washington. 1905. Price, 5 cents.
76. Copper as an Algicide and Disinfectant in Water Supplies. 1905. Price, 5 cents.
77. The Avocado: A Salad Fruit from the Tropics. 1905. Price, 5 cents.
79. Variability of Wheat Varieties in Resistance to Toxic Salts. 1905. Price, 5 cents.
80. Agricultural Explorations in Algeria. 1905. Price, 10 cents.
81. Evolution of Cellular Structures. 1905. Price, 5 cents.
82. Grass Lands of the South Alaska Coast. 1905. Price, 10 cents.
83. The Vitality of Buried Seeds. 1905. Price, 5 cents.
84. The Seeds of the Bluegrasses. 1905. Price, 5 cents.
85. Principles of Mushroom Growing and Mushroom Spawn Making. 1905. Price, 10 cents.
86. Agriculture without Irrigation in the Sahara Desert. 1905. Price, 5 cents.
88. Weevil-Resisting Adaptations of the Cotton Plant. 1906. Price, 10 cents.
89. Wild Medicinal Plants of the United States. 1906. Price, 5 cents.
90. Miscellaneous Papers. 1906. Price, 5 cents.
91. Varieties of Tobacco Seed Distributed, etc. 1906. Price, 5 cents.
94. Farm Practice with Forage Crops in Western Oregon, etc. 1906. Price, 10 cents.
95. A New Type of Red Clover. 1906. Price, 10 cents.
96. Tobacco Breeding. 1907. Price, 15 cents.
97. Seeds and Plants Imported. Inventory No. 11. 1907. Price, 15 cents.
98. Soy Bean Varieties. 1907. Price, 15 cents.
99. Quick Method for Determination of Moisture in Grain. 1907. Price, 5 cents.
101. Contents of and Index to Bulletins Nos. 1 to 100. 1907. Price, 15 cents.
102. Miscellaneous Papers. 1907. Price, 15 cents.
103. Dry Farming in the Great Basin. 1907. Price, 10 cents.
104. The Use of Feldspathic Rocks as Fertilizers. 1907. Price, 5 cents.
105. Relation of Leaf to Burning Qualities of Tobacco. 1907. Price, 10 cents.
106. Seeds and Plants Imported. Inventory No. 12. 1907. Price, 15 cents.
107. American Root Drugs. 1907. Price, 15 cents.
108. The Cold Storage of Small Fruits. 1907. Price, 15 cents.
109. American Varieties of Garden Beans. 1907. Price, 25 cents.
110. Cranberry Diseases. 1907. Price, 20 cents.
112. Suprarenal Glands in Physiological Testing of Drug Plants. 1907. Price, 10 cents.

[Continued on page 3 of cover.]

U. S. DEPARTMENT OF AGRICULTURE.
BUREAU OF PLANT INDUSTRY—BULLETIN NO. 177.
B. T. GALLOWAY, *Chief of Bureau.*

A PROTECTED STOCK RANGE IN ARIZONA.

BY

DAVID GRIFFITHS,
AGRICULTURIST, OFFICE OF FARM MANAGEMENT.

ISSUED APRIL 19, 1910.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1910.

BUREAU OF PLANT INDUSTRY.

Chief of Bureau, BEVERLY T. GALLOWAY.
Assistant Chief of Bureau, G. HAROLD POWELL.
Editor, J. E. ROCKWELL.
Chief Clerk, JAMES E. JONES.

OFFICE OF FARM MANAGEMENT.

SCIENTIFIC STAFF.

William J. Spillman, *Agriculturist in Charge.*

D. A. Brodie, David Griffiths, and C. B. Smith, *Agriculturists.*

J. H. Arnold, Levi Chubbuck, Charles E. Hoke, M. E. McCulloch, A. D. McNair, G. E. Monroe, Harry Thompson, and E. H. Thomson, *Experts.*

J. C. Beavers, G. A. Billings, M. C. Burritt, J. S. Cates, J. S. Cotton, H. R. Cox, M. A. Crosby, D. H. Doane, L. G. Dodge, J. A. Drake, L. W. Ellis, J. W. Froley, C. L. Goodrich, Byron Hunter, H. B. McClure, J. C. McDowell, H. A. Miller, W. A. Peck, A. G. Smith, J. A. Warren, and B. Youngblood, *Assistant Agriculturists.*

C. M. Bennett, M. O. Bugby, E. L. Hayes, M. M. Offutt, E. A. Stanford, and G. J. Street, *Special Agents.*

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief,
Washington, D. C., January 11, 1910.

Sir: I have the honor to transmit herewith and to recommend for publication as Bulletin No. 177 of the series of this Bureau a manuscript entitled "A Protected Stock Range in Arizona," by Dr. David Griffiths. This paper has been submitted for publication by Prof. W. J. Spillman, Agriculturist in Charge of the Office of Farm Management.

This is the second report upon range investigations in the Santa Rita National Forest in cooperation with the University of Arizona. It portrays the effects of proper protection of the native pastures of the region and shows that results are much more certain of accomplishment by proper management than by attempting reseeding operations.

Respectfully,

A. F. Woods,
Acting Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

CONTENTS.

	Page.
Introduction	7
Early history of the inclosed area	7
History of the area since 1903	8
Surface covering	9
Conditions inside and outside of the fenced area	10
Natural reseeding	11
Artificial reseeding	12
Temporary changes in vegetation	14
Permanent changes in vegetation	15
Peculiarities of the feed	17
Weeds	17
Yield of vegetation	19
Carrying capacity	21
Increase of shrubs	21
Summary	24
Index	25

ILLUSTRATIONS.

PLATES.

Page.

PLATE I. Pastures showing improvement due to two years' protection by fencing. Fig. 1.—Range land inside and outside of the fenced area in June, 1903. Fig. 2.—Range land inside and outside of the fence line in April, 1905 8

II. Comparative growth of grass on range lands in a good and a poor season. Fig. 1.—Field of Bouteloua rothrockii in a good season, 1908. Fig. 2.—Field of Bouteloua rothrockii in a poor season, 1907 14

III. Views in the inclosed area. Fig. 1.—A close view of the southeastern portion of the inclosed area. Fig. 2.—General view of the southeastern portion of the inclosed area 16

IV. Two grasses growing in the inclosed area. Fig. 1.—Muhlenbergia porteri growing under the protection of a cat-claw. Fig. 2.—Isocoma coronopifolia growing on range land 18

V. Heavily grazed pastures in the smaller inclosure. Fig. 1.—A badly overgrazed area in the "MacB." pasture. Fig. 2.—Upper portion of the 590-acre pasture, showing spring vegetation under heavy grazing 20

VI. An arroyo and a perennial-grass field in the inclosed area. Fig. 1.—An arroyo producing brush and cacti but very little grass. Fig. 2.—Field containing Baileya multiradiata, a conspicuous plant about the lower border of the perennial-grass region 22

TEXT FIGURE.

FIG. 1.—Map of fenced pastures in the Coronado National Forest, compiled from maps by the United States Geological Survey, the Forest Service, and the Bureau of Plant Industry 8

B. P. I.—547.

A PROTECTED STOCK RANGE IN ARIZONA.

INTRODUCTION.

This report is one of progress simply and is necessarily incomplete, the details being purposely omitted. Many essential facts are also left out, because they have been included in a previous bulletin [a] of the series of the Bureau of Plant Industry.

The investigations really date from 1903, when a tract of land 49.2 square miles in area upon the Coronado National Forest was closed to grazing by arrangement with the Forest Service and in cooperation with the agricultural experiment station of the University of Arizona. Since that time another small tract of nearly a section has been inclosed and cooperative arrangements entered into with four ranchers contiguous to the south and east line of the large tract whereby the investigations will be considerably benefited in extent of territory, diversity of conditions, and interpretation of results by practical range operators. The map, figure 1, shows the area covered and the locations of the different pastures. A record of the operation of these areas under different systems of management during the next few years ought to throw important light upon the value of the proper handling of these semidesert lands.

EARLY HISTORY OF THE INCLOSED AREA.

Before the inclosure of this area it was open range, and large herds have fed here for years. The cattle usually come over in the fall from the other side of the mountains and remain until the April round-ups. In the upper portion of the field there was once a ranch of one of the largest cattle companies of southern Arizona, which has always been heavily grazed, but much heavier in times past than during the last few years before the inclosure was made. All in all, it may be said that heavy pasturing was the rule here for many years previous to that time. (Compare the two illustrations shown in Plate I.) A portion of the area farthest from water, mostly on the edge of the perennial-grass

[a] Bulletin 67, Bureau of Plant Industry, U. S. Dept. of Agriculture, entitled "Range Investigations in Arizona." 1904.

area, was grazed only during the wet season when it could be reached by stock. It was therefore in much better condition than that lying closer to the mountains, where water was more convenient.

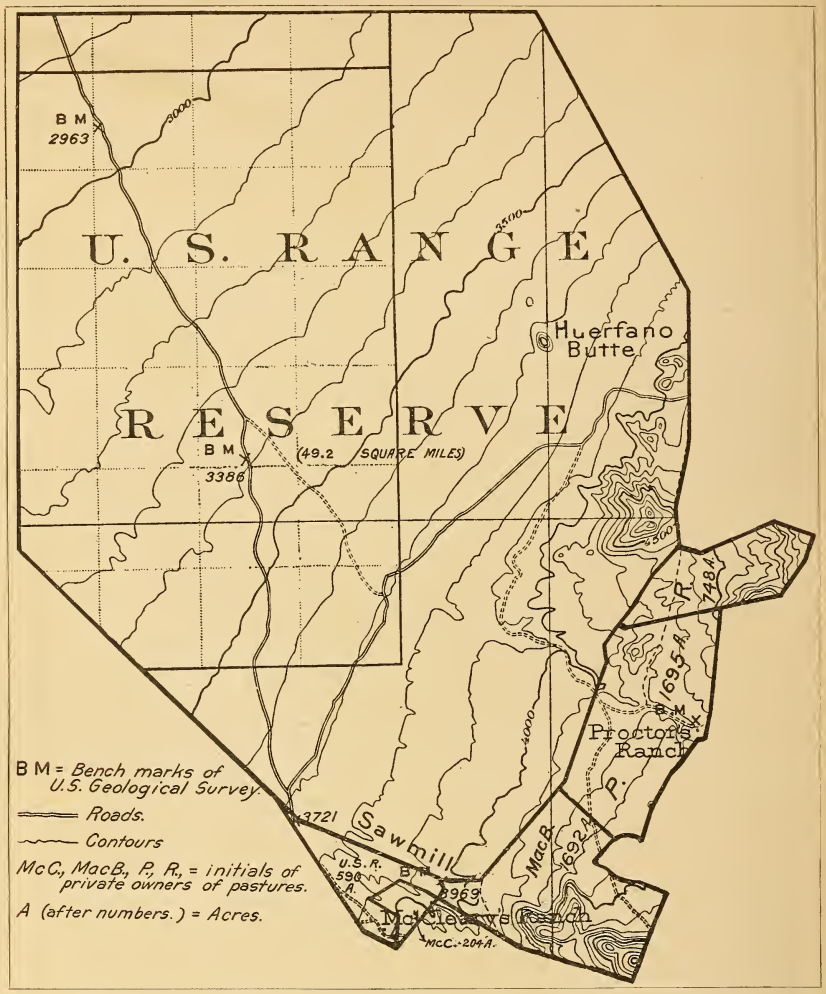

FIG. 1.—Map of fenced pastures in the Coronado National Forest, compiled from maps by the United States Geological Survey, the Forest Service, and the Bureau of Plant Industry.

HISTORY OF THE AREA SINCE 1903.

The large field was inclosed in June, 1903. By the first of the year 1908 the pastures marked upon the map (fig. 1) *P.*, *R.*, and *MacB.* were sufficiently inclosed to permit the control of stock in them, and the inclosures were completed later. These areas were inclosed by ranchers in cooperation with the Department of Agriculture. The 204-acre pasture was inclosed years ago and has been moderately

FIG. 1.—RANGE LAND INSIDE AND OUTSIDE OF THE FENCED AREA IN JUNE, 1903.

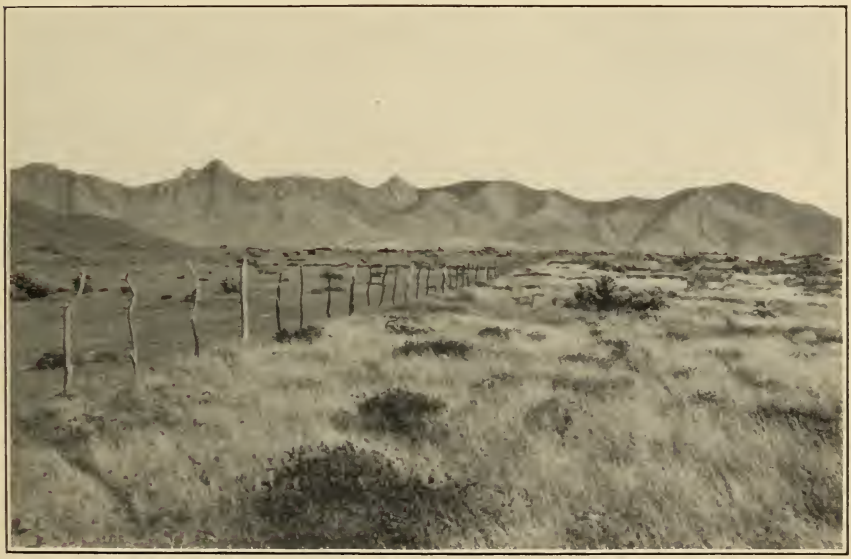

FIG. 2.—RANGE LAND INSIDE AND OUTSIDE OF THE FENCE LINE IN APRIL, 1905.

PASTURES SHOWING IMPROVEMENT DUE TO TWO YEARS' PROTECTION BY FENCING.

stocked ever since. A large part is in heavy brush, and consequently not as productive as it would otherwise be. A few head of stock have been allowed in the 590-acre pasture since it was fenced, but the large area has had no stock upon it since it was inclosed except an occasional stray. The pastures *P.*, *R.*, and *MacB.* have been handled by their owners very much as their judgments dictated, a record being kept in all cases of just what treatment each pasture received.

SURFACE COVERING.

The accumulation of dead herbage upon the surface of the soil of the area takes place very slowly. When the growth first dries up in the fall after a good rainy season there is an accumulation of, perhaps, a thousand pounds of dry matter to the acre. This is enough to make a big fire if ignited shortly after the dry season sets in. If left upon the ground for one year in this climate, however, it largely disappears, from the action of wind and weather, so that the accumulation, while surely taking place from year to year, is very slow. In this inclosure after six years of protection there is in no portion of it a complete ground cover during the entire year. There is, it is true, at the close of the rainy season grass two feet or more high in some places, but, as is characteristic of desert vegetation, it is thin and largely disappears before the next season. In the lower portion of the field, where the annual grasses predominate, the accumulation is next to nothing, but it gradually increases toward the higher level and is most abundant in the extreme southern portion of the inclosure. (See Pl. IV, fig. 2.) The occurrence of a dry year largely obliterates any cover that may have accumulated during the previous season. In short, even after six years of protection there is now in the lower portion of the field practically no ground cover, and in all probability there never has been any. In the upper portion, while the growth increases under protection, there is yet only about half a cover on the ground during the entire year. In the upper country, at an altitude of 3,500 feet and upward, a large accumulation of dead herbage can be kept upon the ground under a good system of management, as is being done in some private and cooperative pastures in the region now, but below this altitude the ground cover is not a factor of much consequence, for the grasses are mostly annual. Of course, upon the swales which receive flood waters the galleta and other grasses make a large growth and protect the surface, but such areas do not occur in the inclosures here described.

It will be seen that the matter of growth is one of distribution of moisture, which is influenced by altitude. As stated elsewhere, the rainfall quoted in this paper is taken in the 204-acre pasture. This point probably receives more rainfall than any portion of the large inclosure, the precipitation decreasing gradually northward until one

reaches a point where it is too light to support the perennial grasses. However, a few miles to the northeast of the field there is an area of lower ground where hay has frequently been cut, but this is due to the spread and accumulation of flood waters over the surface. It is more than probable that the rainfall where the gauge is located is from 1½ times to twice that in the lower (northern) portion of the field, which represents more closely the conditions obtaining around Tucson. Besides, the distribution of rainfall is much better in the upper portion of the inclosure, more frequent rains occurring than in the low altitudes.

CONDITIONS INSIDE AND OUTSIDE OF THE FENCED AREA.

Upon the north and the west sides of the field there is practically no difference between the inside and the outside of the inclosure. There are two reasons for this. The north and northwest portions are the least productive of the field, and in this neighborhood water is a long way off, so that the stock graze here very little. Indeed, there have been but few cattle in the vicinity of the fence from the private pastures to the northwest corner for two years. (See map, fig. 1.) As a consequence, upon the southwest side a small crop of hay was cut on the outside of the fence last year.

On the east side, outside of the inclosure, the pasture is very short, having been grazed for years by horses and sheep. The conditions here are most instructive. The year 1908 was a favorable one and, consequently, in spite of the heavy grazing, some of the valuable perennial grama grasses matured seed to a much greater extent than in former years. This illustrates the extreme persistency of these grasses. They may be greatly abused even in this easily eroded and parched region, but when a favorable season occurs they again make their appearance and will, if husbanded for a few years, regain their supremacy. There is no doubt that there was at least ten times as much growth of these valuable perennials in 1908 as there had been for the previous three or four years. On the whole, there was in 1908 a fairly good crop of vegetation on this badly denuded region tributary to Helvetia, but it consisted in largest measure of the six-weeks' grasses, which are the poorest in the region.

From McCleary's south gate to Helvetia the area next to the government fence is now entirely protected by private holdings. (See map, fig. 1.) Although some of these have been only partially protected from the very excessive grazing of the previous years for somewhat less than twelve months, there is a phenomenal difference between them and the outside range. In one instance an inclosure of nine months' duration can be recognized for a distance of six or more miles even though the area has been grazed moderately all the time.

NATURAL RESEEDING.

Nature is normally profligate in her seed supply. It seems at times, especially with desert plants, that germination will insure seed production; in other words, many plants which have sufficient moisture for germination seldom fail to produce some seed. Indeed, in an average season the annual plants of the desert produce enough seed to restock the same land and insure as large a subsequent crop as the sterile soils can maintain. A small percentage of the more common plants grow each year and in turn produce seed. As an example we might cite *Bouteloua aristidoides*. A season is seldom so dry that some of this grass will not grow and produce seed. The plants may be a foot high and yield very little seed, or the spikes in a favorable year may equal the entire length of the plant in an unfavorable one.

It is different, however, with the perennial grasses. A season which produces an abundance of seed may be followed by one unsuited to the growth of seedlings, and consequently the crop of seed, although it falls to the ground, may be largely lost. Since the Department's operations in the Santa Rita Mountains were begun there have been but two years favorable for reproduction. The season of 1907, although not so prolific as the subsequent one, produced an abundance of seed of *Bouteloua rothrockii* and *Bouteloua bromoides*, two of the most important grasses in this region. This was followed by a very favorable season in 1908. There was consequently an exceptionally good growth of seedlings that season. It is quite possible that the seedlings of these two grasses over the entire areas in which they are peculiarly characteristic would average from four to six to the square foot. These seedling plants were all well established and in thrifty, vigorous growing condition on October 1, 1908.

The condition of these seedlings the next season was not only of scientific interest but of exceeding economic importance. If they all grew to maturity and produced plants the next year as vigorous and large as those that grew on the same area the yield ought to be increased 50 per cent, other conditions being equal. This condition, of course, was beyond the range of probability, because such a yield would be beyond the capacity of these desert lands to produce. As a matter of fact it is doubtful whether the yield of perennials in the upper portion of the field was much greater in 1909 than in 1908, in spite of the large number of seedlings of 1908. Natural selective influences work to thin this stand to the typical thin, scattering, bunchy condition best adapted to maximum production upon arid lands, a principle becoming better and better recognized in the growing of farm crops with small amounts of rainfall. Thin seeding is now recognized to be best under such conditions. The difference

between a good crop and a small one in the perennial-grass region of these deserts is not so much due to a larger number of plants as to larger plants or clumps of plants.

Our experience upon this inclosed tract seems to indicate that the natural restocking of the perennial range by new plants takes place at irregular intervals. The ratio of increase may bear no relation to the quantity of seed produced the previous year. In other words, a favorable season for seed germination following a poor season of seed production may develop vastly more seedlings than one of poor distribution of moisture following an abundant seed production. Since this area was fenced, there has been but one season when the production of perennial-grass seedlings failed almost entirely. On the other hand, there have been but two years in five when a decided increase was noticed, the increase in 1907–8 being enormously greater than any of the others.

ARTIFICIAL RESEEDING.

Many attempts have been made to introduce forage plants in this section, both in the large inclosure and upon the holdings of private individuals in the vicinity. There is but one species that has given any beneficial results. Alfilerilla (*Eurodium cicutarium*) has been tried several times and in various situations. In brushy pastures in the upper foothills it has produced a thick mat of herbage some years, while in others the growth has been poor. All in all it has done well in patches, but only in the most favorable situations, in rather loose soil, where the grazing has been quite heavy and there is open mesquite brush. This plant grows in the winter; consequently, the shade furnished by the mesquite is at a minimum when the plant grows. It has taken four or five years for it to become well established.

In the open foothills, where the best pasture is found, the growth of this plant has been of no consequence. It has been started in several places, and indeed there were patches of it to be found in several situations when the field was inclosed, but even these have not spread. In short, the plant does not appear to be able in this situation to compete with native vegetation when the latter is not grazed. In one locality, along the fence line, there has been for years a patch of a few acres established no one knows how, but probably by sheep. This has been watched with interest, but the growth of alfilerilla has been less under protection than in the open where the land was heavily grazed.

In all, some two hundred species of forage plants have been planted in this inclosure. Many native species were tried, but the vast majority used were of foreign importation. At one time the Office of Forage-Plant Investigations of the Bureau of Plant Industry fur-

nished more than one hundred varieties for testing. In some cases the seed was covered and in others scattered without any further attention. The plan has been, whenever the quantity of seed permitted, to sow one-half in the fall and one-half in the early summer. In some cases the ground was worked up sufficiently to kill about half of the original vegetation.

The net economic result of all this foreign introduction has been practically nil. It is not necessary to go into details regarding these plantings, even to the extent of publishing a list of the seeds planted. Most of the species, in our experience, have never come up, and the few things that did make any growth usually died before seed was produced.

In 1906 large quantities of wild oats (*Avena fatua* and *A. barbata*) were planted in June. Germination was very good, and by the 1st of January, 1907, the plats were promising, but the plants soon dried up, never getting over about 2 inches high. The seed did not germinate until the winter rains set in. The previous year seed of bur clover (*Medicago denticulata*) from California was sown in large quantity and well covered. It started beautifully, but dried up and died in April when about 2 inches high, with no seed production.

Tucolote (*Bromus maximus*) matured a few plants from one of the several seedings made, but seems to have disappeared entirely. This is one of the most aggressive species upon the California ranges. It might not be a detriment here, for it is a winter annual, and therefore would come in competition with only weedy spring plants and would probably have no effect on the crop of forage which comes in summer.

Results in reseeding, so far as these experiments have progressed, can be secured much more satisfactorily by the use of seed of native forage plants than by the use of the seed of plants from foreign countries. But even with these the results are not commensurate with the expense of getting the seed and growing it. Much more satisfactory results have thus far been obtained by husbanding the native vegetation and grazing well within the capacity of the land to maintain stock. In short, so far as information gained from experiments thus far conducted is concerned, these lands, although very badly overgrazed, will return approximately to their original productivity under complete protection in about three average years. Complete protection, however, is not necessary, though of course it will take longer to restore lands to their full productivity when grazing is practiced.

These remarks apply only to the plants already tried, the majority of which had some claim to succeeding in dry situations. It is not impossible that some foreign plants may yet be found which will succeed here, and all which have any chance of success should be tried. But meantime proper handling of the native vegetation is

urged—a system of grazing which it is well within the capacity of the land to maintain.

A number of native grasses have been caused to spread successfully by gathering the seed in advantageous localities and simply scattering it where the ground was badly denuded. Better results have been obtained when seeding was done the last of June or the first of July. When sown in autumn the ants pick up too many of the seeds. Beneficial results have been secured in this way by the use of the seed of *Andropogon saccharoides*, *Bouteloua vestita*, and *B. rothrockii*. Less positive results have been secured by the use of native seed of *Bouteloua curtipendula* and *Leptochloa dubia*. Indifferent results have been secured with *Bouteloua oligostachya*. It should be noted that the last is a very important grass on the east side of the Santa Rita Mountains, but, so far as the writer knows, it does not occur on the northwest side of the divide except in one small, well-established patch. The origin of this is not certain, but it is believed that it was established by seeding done in 1901. It is a beautiful, vigorous growth in a place which was badly denuded at that time.

The above illustrations of the successful use of native species are important and interesting, but they have no applicability to open-range conditions. However, where the land is under fence and seed can be secured in the vicinity without too much expense, improvements can be made in very badly trampled areas. When the roots of the native growth are not completely destroyed, it is questionable whether in such situations as this recuperation would not occur fully as rapidly by proper protection from overgrazing without the use of seed as with it.

It must be remembered that the chances of failure of seed in such a region are very great. It is not necessary to discuss at length the contributing causes. They are many. The most important are the irregularity and the uncertainty of the rainfall.

TEMPORARY CHANGES IN VEGETATION.

The most striking changes in vegetation are those which take place from year to year in annual plants, and this is always noticeable in any region where the annual vegetation predominates. As a concrete example, the growth upon one of the inclosures in 1907 may be compared with that of 1908. In a badly denuded portion of one of the fields a blue-flowered, aster-like composite (*Machalranthera* sp.) was decidedly conspicuous. It was estimated that in 1907 one could have cut with a mower at least 500 pounds of dry matter to the acre from a large area. In 1908 one would have been obliged to cut not less than 30 acres to secure 500 pounds. The only place that the plant grew the second year was along washes and rivulets, which,

FIG. 1.—FIELD OF BOUTELOUA ROTHROCKII IN A GOOD SEASON, 1908.

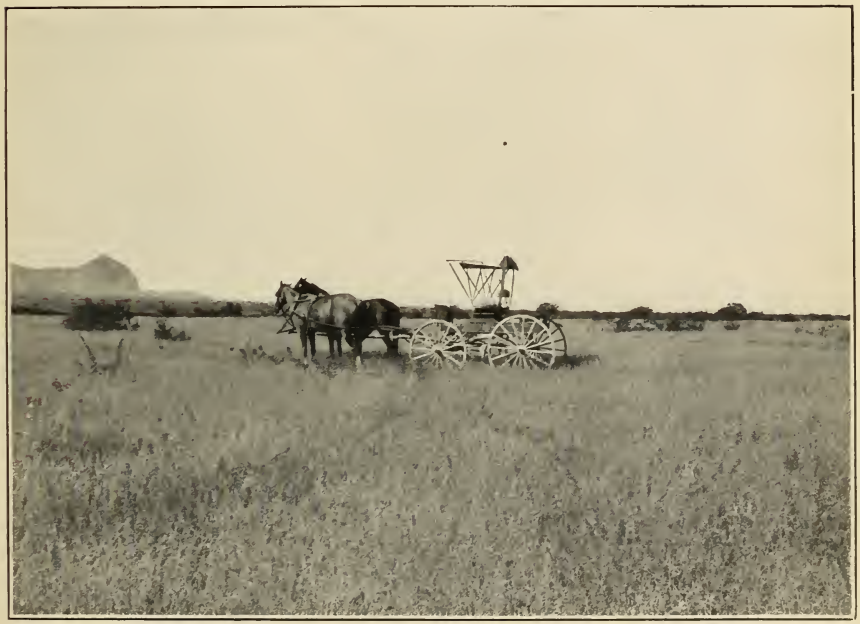

FIG. 2.—FIELD OF BOUTELOUA ROTHROCKII IN A POOR SEASON, 1907.

COMPARATIVE GROWTH OF GRASS ON RANGE LANDS IN A GOOD AND A POOR SEASON.

however, never had water except during a rain. In 1908 this aster-like plant was supplanted by *Bouteloua aristidoides, Aristida bromoides,* and other weedy annual grasses. Besides these, there was a thin and very irregular growth of such valuable perennials as *Bouteloua rothrockii, Bouteloua bromoides, Leptochloa dubia,* and *Bouteloua vestita.* This area was in the 590-acre inclosure (marked U. S. R. on the map, fig. 1). The changes were more noticeable than in the large field because the small field was more completely denuded of its vegetation. It is quite probable that the productive capacity of the small field is much below the average of similar portions of the other field.

But such differences in vegetation, comparing one year with another, are very striking. There has not been one year in ten when there was such a crop of *Plantago fastigiata* throughout the region (see Pl. V, fig. 2) as in the spring of 1901. In the large field, even with similar rainfall, there occurs an ascendency of one plant one year and of another plant another year, and this is more especially true of the growth of the spring season, which is more truly annual. One year the Arizona lupine (*Lupinus arizonicus*) gives its characteristic color to the landscape. Another year may witness the same with reference to *Orthocarpus purpurascens palmeri. Lotus humistratus* may be the abundant species another year, and *Pectocarya linearis* another. In the upper portion of the large inclosure at the present time there is a good stand of perennial grasses. These grow in the relatively humid summer season. During the summer there is a very sparse growth of annuals. In the spring, however, this region which grows grass in summer has its complement of annuals, and the relative abundance of the species varies about the same as it does on the lower portion of the field, where the perennials do not occur.

So far as known, no one has ever offered an explanation for these yearly variations of annual vegetation. The change in the aspect and balance of the species occurs in the annuals only. There has been no change, so far as anyone can see, in the areas of *Bouteloua rothrockii, Bouteloua bromoides, Aristida divaricata,* or *Aristida californica* in the large inclosure since the beginning, excepting a gradual thickening up of the respective species and a consequent shutting out of the annuals. (See Pls. II and III.)

PERMANENT CHANGES IN VEGETATION.

The rancher in this region is only half wrong when he asserts, as he commonly does, that the six-weeks' weedy and low-quality grasses have recently taken the range and driven out what he calls "root grasses," or the more valuable perennials. It is only the last portion of the statement that is false. The perennials, or more valuable

species, have, it is true, disappeared, but they were not driven out by annuals, but, on the contrary, by the rancher's cattle.

The annual grasses of this region, such as *Bouteloua aristidoides* and *Aristida bromoides*, are not much relished by stock. They have harsh, hard glumes which penetrate the flesh. They dry up early, leaving but little substance, and, more than all this, they pull up by the roots when grazed and carry with them sand and dirt. They are therefore not eaten while the perennials are available. When the latter become impoverished by excessive grazing the former flourish. The ranges have therefore at present a larger proportion of weedy annuals, not because the latter are more aggressive, but because the former have been impoverished and to a large extent in many sections killed out by overgrazing.

One thing at least has been conclusively proved in this experiment, i. e., that the perennials which once flourished here and which have been decidedly injured by stock will again regain their ascendency over the weedy annuals when given a measure of protection. The *Bouteloua rothrockii* and *Bouteloua bromoides* areas were not only less productive of these perennial grasses when the inclosure was made but were actually more productive of the annuals *Bouteloua aristidoides* and *Aristida bromoides*. (See Pls. II and III.) The gradual encroachment of the perennials upon the region of annual grasses has been one of the most notable features since the area was inclosed, and is yet in all probability only partially accomplished.

The regaining of ascendency by the perennials is slow here, much slower than in regions favored by a more equitable rainfall. As stated elsewhere, it is only in an occasional season that seed of the perennials appears to find conditions congenial for growth. This, coupled with the fact that the annuals invariably encroach at this altitude whenever the perennials are injured, renders the process of recuperation slow here compared with that in northern regions of more favorable rainfall and a less easily eroded soil.

On the other hand, the increased growth of an even partially protected area is phenomenal. One of the inclosures completed very late in 1907 can be distinguished at the present time for miles by the difference between the character of its vegetation and that of the vegetation outside, and it has been grazed continuously at that, but only moderately.

Last season one of the fields inclosed was as badly grazed as the Macaranthera area already referred to, but grew a fine crop of a yellow annual composite. Although it was in one of the best perennial-grass regions on the west side of these mountains, there was practically no grass there except a poor growth of the six-weeks' varieties. This season there is, of course, after such excessive graz-

FIG. 1.—A CLOSE VIEW OF THE SOUTHEASTERN PORTION OF THE INCLOSED AREA.

FIG. 2.—GENERAL VIEW OF THE SOUTHEASTERN PORTION OF THE INCLOSED AREA.

VIEWS IN THE INCLOSED AREA.

ing, only a moderate growth of the perennials, but at least tenfold as much as there was last year, and a very heavy growth of the annuals. Judging from what has taken place upon the first large inclosure, the annuals will gradually give way to the perennials during the next four or five years and at the same time withstand a considerable amount of grazing.

Below an altitude of about 3,500 feet we come to the desert proper, where the summer grasses are mainly of the annual type, always have been, and probably always will be. Below this altitude the only perennial grasses are those which are favored by occasional irrigation, in long arroyos and swales, where the drainage from higher levels spreads out over them. There is no hope of establishing perennials upon the lower, unirrigated mesa lands. When rains are favorable the low-lying regions will produce some indifferent feed in the shape of annuals, and that is all that can be hoped for them.

PECULIARITIES OF THE FEED.

The appearance of the feed upon the ground is deceptive in any desert country, but more especially in the area described in this bulletin. The growth is invariably thin, but it may be quite tall, especially in favorable years, making difficult an estimate of the quantity of feed produced. This is true of the growth in general upon a desert region. The most deceptive grass of all is the one locally known as black gama (*Muhlenbergia porteri*). (See Pl. IV, fig. 1.) In early days this grass was exceedingly conspicuous, growing in tangled masses 2 to 3 feet high, both in clumps of shrubbery and in the open. The pioneer stockman calculated the productivity upon what he saw of this species, supposing that he was dealing with a grass of ordinary character. But the pioneer saw three or four years' growth, for the culms of this grass are perennial, only the terminal joints dying back each season. When, therefore, an area is unpastured for a time there is actually an accumulation of feed from year to year of this grass and some others, while the ordinary grasses die and grow up again from the roots each year. The deception is really serious, as is readily seen if one mistakes three or four years' growth for one and stocks the land accordingly. This is precisely what has happened in many cases. It is no wonder that some managers of stock companies insisted that the country could not be overstocked, nor, indeed, would it probably be if the production which the pioneer saw could be repeated with certainty each year.

WEEDS.

There are really but two weeds in the inclosure, but they are both somewhat serious. One is one of the rayless golden-rods (*Isocoma coronopifolia*) (Pl. IV, fig. 1), not distantly related to the sheep weeds

and snake weeds of New Mexico, Texas, and northern Arizona. Here this plant has spread upward from the river bottom and now occupies the rocky ridges and mesas between the grassy section and the more level desert lands below. It has thickened and increased perceptibly during the last five years. The rainfall in the region where it is most abundant was very light in 1908, and it consequently made but little growth. No one can tell what the future of this plant may be; it is quite probable that the grasses unmolested would hold their own against its encroachments, but with the grassy vegetation weakened by grazing it may increase to such an extent as to crowd out nearly all of the valuable plants, as is done over thousands of acres in other regions by species of Gutierrezia.

Remedies which are effective and at the same time economically applied in the control of the variety of rayless golden-rod mentioned have not been perfected as yet. Burning in the dry season in summer will kill some species of the group. In other words, if there is sufficient herbage upon the ground to burn during the vegetative condition of these plants they will be killed by burning the land over, but burning during the winter season, when they are dormant, will not kill them.

In the region under consideration the golden-rod referred to has increased mainly below the grassy area, such increase having taken place but partially during the time that the area has been under protection. The encroachment evidently had begun years before. It is not yet thick enough to burn, even during the dormant dry season. Should all the young plants in evidence in 1908 come to maturity, which is rather improbable, it would be thick enough to burn in two or three years. The grasses do not become abundant enough here to allow of burning. The weed is increasing in the lower grassy areas, but principally in that region which now, as probably always, is producing mainly annual grasses. How far it will increase in the perennial-grass areas and how its encroachments within and without the fence will compare can not yet be satisfactorily judged. It must be remembered that it takes very much longer to secure positive results in matters of this kind in this region of scanty rainfall than in more favored localities. There are indications that the plant has about reached the limit of its growth here, as the sheep weeds have elsewhere, and like them has begun to die. In 1909 a large proportion of the plants were dead and none were as vigorous as in previous years, although the season was exceptionally favorable.

The only other real weed is the loco weed (*Lupinus arizonicus*). This is supposed to have done much damage to the horse industry, but does not appear to be as injurious to cattle. So serious is the matter considered that at least one rancher in the vicinity has gone out of the horse business entirely.

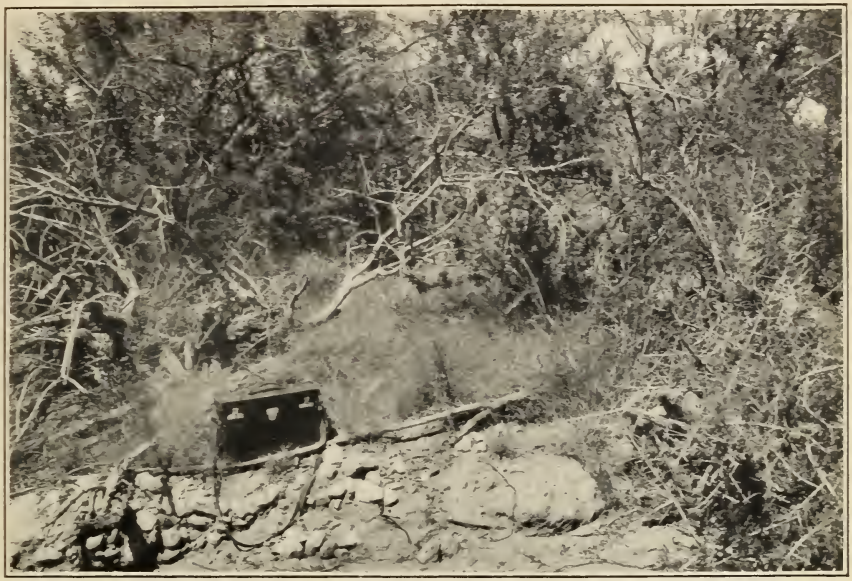

FIG. 1.—MUHLENBERGIA PORTERI GROWING UNDER THE PROTECTION OF A CAT-CLAW.

FIG. 2.—ISOCOMA CORONOPIFOLIA GROWING ON RANGE LAND.

TWO GRASSES GROWING IN THE INCLOSED AREA.

This lupine is an annual plant which grows in the winter rainy season. It is conspicuous in the southern portion of the inclosed area in February and March. In favorable seasons it gives its characteristic blue color to the landscape upon hillsides and bluffs along arroyos. Even this plant is closely grazed by cattle, with, as already stated, apparently no injury. Upon the outside of the area it is grazed as closely as any other forage plant and seems to be as readily destroyed by such grazing as any of the valuable feeds. In the spring of 1908 it was difficult to find any of this plant outside of the fence in localities where it has been very abundant. The rayless golden-rod is the only conspicuous weed not touched by stock.

YIELD OF VEGETATION.

During the time that the area has been under fence an effort has been made to get a quantitative estimate of the amount of herbage produced from year to year. The estimate is based upon measurements of definite plats scattered over the entire field in such a way as judgment dictated would give an average yield. Only the briefest outline of the data secured is given here. The method of measurement is given in Bulletin 67 of this series and need not be repeated here in detail. In general it may be said that the vegetation of plats containing 21 square feet was measured, these plats, eighteen to twenty in number, being scattered over the entire field, as indicated in Bulletin 67. In that publication a more or less detailed discussion is given of methods employed in making these computations, which need not be repeated here. Inasmuch as these are more or less estimates anyway, it is not important that in this paper a slightly different method of computation is used from that in Bulletin 67. The comparisons are not altered.

The results of these measurements are given in the following table:

TABLE I.—*Average yield of forage on plats of 21 square feet each in the fenced area on the Coronado National Forest.*

Year.	Season.	Rainfall.	Seasonal yield.	Annual yield.
		Inches.	*Pounds.*	*Pounds.*
1903	Spring	3.29	520.55	791.02
	Summer	7.48	270.47	
1904	Spring	2.64	14.13	412.45
	Summer	8.24	398.32	
1905	Spring	20.70	799.00	1,174.94
	Summer	6.14	375.94	
1906	Spring	9.88	(a)	(a)
	Summer	3.27		
1907	Spring	7.98	435.88	1,151.76
	Summer	12.03	715.88	
1908	Spring	9.36	300.88	1,225.55
	Summer	10.67	924.67	

[a] No measurements.

In the production of the two crops of feed which we have in the region of the Coronado National Forest two seasons of rainfall contribute. The season which produces the spring crop is much more indefinite than the one producing the summer crop and the crops themselves are very different. The spring feed consists of weedy annuals, and the summer feed of grasses, both annual and perennial.

The winter rainy season, as it is usually called, may begin as early as October and may last through April, or it may be foreshortened at either end and even almost disappear at times. The summer rainy season, on the other hand, is short, commonly better distributed, and occurs in July, August, and September. In the column in Table I showing rainfall, that recorded under the spring season fell between October and April, and that under the summer season in July to September. The rainfall of May and June is negligible and seldom has any influence on feed production.

The rainfall record is taken in the 204-acre pasture shown on the map (fig. 1).

In a general way Table I shows that the yield is dependent upon the quantity of rainfall. Quantity, however, is not the only factor, as will be readily seen. Its distribution is of extreme importance. This feature is not shown in the table. It can be shown only by a detailed account of the precipitation, which it is not considered necessary to publish at this time. The most important point of all brought out by the table is the comparative uniformity of production during the last years and the increase over earlier years. Both of these facts tend to show that the production of the field has been decidedly on the increase and that it may now be at its maximum, which was reached in about three years after its inclosure. Whether the production from now on will be dependent upon rainfall alone remains to be seen, but so far as these records go that is to be expected. It is also to be expected that from now on there will be little, if any, increase in production due entirely to protection. On the other hand, yield alone is only one phase of the improvement which may take place. As pointed out elsewhere, this improvement may be as much a matter of the supplanting of annuals by perennials of greater value as it is of actual number of pounds of feed produced. This improvement, it is believed by the writer, will take place to some extent under future protection, but it is believed that the maximum tonnage has been reached and that future fluctuations will be due in largest measure to variation in rainfall.

The general correlation between the rainfall and the yield of forage is of course very striking, as rainfall is always the most important factor of production here. But the production of 520 pounds of forage on 3.29 inches of rainfall in the spring of 1903 is out of all

FIG. 1.—A BADLY OVERGRAZED AREA IN THE "MACB." PASTURE.

The greater part of the vegetation consists of worthless composites and eriogonums. The latter are fairly good feed. Photographed in September.

FIG. 2.—UPPER PORTION OF THE 590-ACRE PASTURE, SHOWING SPRING VEGETATION UNDER HEAVY GRAZING.

HEAVILY GRAZED PASTURES IN THE SMALLER INCLOSURE.

proportion to the production of only 14 pounds on 2.64 inches in 1904. As a matter of fact nearly 2 inches of the rainfall which produced the spring crop of 1904 fell in the months of October to December. This served to germinate the seed very well, but there was not moisture enough in the spring to make any considerable growth. This is a good illustration of the influence of proper distribution of moisture as well as proper quantity.

CARRYING CAPACITY.

As stated elsewhere, the large field has not yet been pastured, the object thus far being to study recuperation under absolute protection. The only data secured on carrying capacity are from the pastures under private cooperative control contiguous to the upper side of this field. The most satisfactory record, all things considered, is from the "MacB." pasture. (See Pl. V, fig. 1.) The record is short, but even the first year after being inclosed the land improved very perceptibly and still maintained stock at the rate of one head to 20 acres. It should be stated that this pasture is about one-fourth in the oak belt and the remainder in the open grass land immediately below. It is probably the best pasture land in this region. The 204-acre pasture is smaller and less productive by far, mainly on account of thick brush. A long record, reaching over five years, is available for this pasture. Four burros and three horses run short of feed in this pasture occasionally. Of course, the brush interferes with the growth of grass somewhat. On the other hand, the mesquite (*Prosopis velutina*) furnishes some beans, which are a valuable forage. Pasture experiments in the large inclosure were begun in the summer of 1909, and the results will be reported later.

INCREASE OF SHRUBS.

Much has been written about the rapid spread of the mesquite (*Prosopis glandulosa*) and other shrubby vegetation in Texas since the advent of flocks and herds, but the development of this class of plants is so much slower on the inclosed area referred to in this paper that it appears to have been in a large measure overlooked. It is, however, taking place just as surely as in Texas; the only difference is that the growth is much less than half as rapid.

The year previous to the inclosure of the large field a small crop of hay was cut over the best portion of its present area. This, however, was far from any water. Acres were harvested where there was no impediment to the mower. At the present time, six years later, there is not an acre in the whole field where there are no shrubs to interfere with the machine. They are still small, half an inch to an inch in diameter at the base, but large enough to stop a mower.

They have made a very perceptible increase within the writer's acquaintance with the area. The prediction is ventured that the time is coming when these foothill grassy areas, which now have only an occasional small shrub, will be as shrubby as the deserts and lower foothills below them, if not more so.

Some of these shrubs do, of course, furnish some feed, but here, as elsewhere, their growth will be largely at the expense of grasses. For a long time the lower foothills, arroyos, and general desert mesas have been shrubby, and the gently sloping tables between the arroyos and the upper foothills are slowly becoming so.

It will doubtless be impossible to depict all the agencies that are bringing about these changes. It is quite certain that the operations here of the Bureau of Plant Industry have had no influence, for the shrubbery has thickened up on the outside of the inclosure, where the grazing has been very heavy, apparently as much as on the inside. The probability is that neither protection nor heavy grazing has much to do with the increase of shrubs here, but that it is primarily the direct result of the prevention of fires. There never was a time when the shrubby lower foothills and desert mesas produced vegetation enough, except in limited localities, to allow fires to spread, but the grassy foothills, which constitute the upper half of our inclosure, produce sufficient vegetation to burn readily, at least every other year, at the present time. Previously, before the country was stocked, it probably produced more grass than it does now, and was frequently burned over, the fire extending as far down as vegetation would permit. Such burning did comparatively little injury to the grasses, but was very destructive to all small shrubs; consequently, these were able to exist only along the sandy washes, where the grasses were least productive, and upon the lower areas, where fires did not molest them.

Upon the brushy deserts below, the rainfall is so scanty that the grass produced is not sufficient to allow fires to spread. Upon the mountains above, the moist season is more prolonged, the grass remains green longer, and the surface is more broken, often with sheer declivities, which are bare of vegetation, all of which render burning less probable. It must be remembered that frequent burnings are not necessary here to keep down brush. Possibly with comparative freedom from grazing a fire once in ten years would suffice in such an area, because growth is very slow.

The memory of early stockmen is not sufficiently retentive to give us much reliable information regarding the location and density of brush upon these areas when their operations began, so it is necessary to make inferences from changes which are occurring now under the changed conditions. Trained observers have not been sufficiently

FIG. 1.—AN ARROYO PRODUCING BRUSH AND CACTI BUT VERY LITTLE GRASS.

FIG. 2.—FIELD CONTAINING BAILEYA MULTIRADIATA, A CONSPICUOUS PLANT ABOUT THE LOWER BORDER OF THE PERENNIAL-GRASS REGION.

AN ARROYO AND A PERENNIAL-GRASS FIELD IN THE INCLOSED AREA.

long associated with the conditions or interested in this phase of desert vegetation to form from memory accurate judgments.

It is true that the grassy belt is noticeably not continuous in these mountains or elsewhere, but on the other hand, the desert mesquite forest often extends quite to the beginning of the real mountain forest. Such a condition is easily accounted for by local influences. In the canyons the growth of timber is continuous from the mountains to the desert, and in places on the ridges and gently sloping mesas as well (Pl. VI, fig. 1). In both cases the writer believes this condition to be due mainly to the comparatively low fertility of the soil in these situations, assisted in the canyons by the excess of water. The bottoms of the canyons are less productive of grass here to-day than the mesas between, owing to the constant shifting of the sands and the washing off of the finer particles of soil by the frequently changing courses of the flood waters. Action of fires was therefore less pronounced in the canyons, allowing trees and shrubbery to get started, as well as when they did get started, furnishing greater moisture in the subsoil.

The main factor, though, in the opinion of the writer, has been that of fire. It is firmly believed that were it not for the influence of this factor the grassy mesas would to-day be covered with brush and trees, the same as the canyons, except that the growth would be smaller, owing to a more limited supply of moisture. In short, the same laws apply here that govern in our great prairie States (see Pl. VI, fig. 2), where the treeless plains were kept so by frequent fires. It is a very conspicuous fact that the continuance of the desert forest, up to the mountains upon the mesas, occurs where the soil is poorest; in other words, upon the lands which produced least grass, and, consequently, the smallest amount of food for fires. This fact is illustrated in one of the pastures, where there is an area of mesquite upon the gently sloping mesa. But this area is naturally poor soil, and its poverty, on account of location close to the terminus of a temporary stream, has been aggregated for many years by excessive grazing. The same remarks apply to the region just north of Helvetia.

The spread of the seed of the mesquite by cattle and horses eating the beans, thus furnishing a good culture for their development, may have some influence, but it is so seldom that seedlings are met with that it is questionable whether cattle or horses have as much influence as has been suggested. They probably do cause a more thorough and widespread distribution, but probably assist the spread of shrubbery more by eating off the grass, so that there is nothing to burn, than they do by distributing the seeds.

SUMMARY.

The lands under consideration in this paper appear to regain their original productivity in approximately three years of complete protection.

Evidence thus far secured seems to indicate that the best lands in the vicinity will improve under stocking at the rate of one bovine animal to 20 acres. The poorer lands take a correspondingly larger acreage for each animal. The areas that will carry now one head to 20 acres are very limited.

Brush and timber are encroaching upon the grass lands, due, it is believed, to protection from fires.

A ground cover is not a factor below an altitude of about 3,500 feet.

Although the maximum yield of forage may be reached in about three years of protection, improvements in quality of forage will probably go on longer through the continued supplanting of annual plants by perennials of greater value.

Thus far alfilerilla is the only introduced plant which has succeeded, and this only in the most favored situations. It does not appear to thrive in competition with the native perennial grasses at these altitudes when the latter are not grazed.

None of the other two hundred lots of seed sown have given any promise of success except those of three or four native species. These give beneficial results, but the cost is high.

Results seem to be secured much more rapidly by proper protection from overgrazing than by any other method.

INDEX.

Page.

Alfilerilla, introduction, experiments 12
Altitude, relation to ground cover 9, 10
Andropogon saccharoides, seeding, experiments 14
Arid regions. *See* Regions, arid.
Aristida bromoides, weedy annual, description, etc 15, 16
californica, vegetation, annual variations 15
divaricata, vegetation, annual variations 15
Arizona, stock range, protected, history, early 7–8
since 1903 8–9
Arroyos, growth of perennial grasses 17
Avena barbata, introduction, experiments 13
fatua, introduction, experiments 13
Bouteloua aristidoides, description 16
drought-resistant, seed-producing plant of arid regions, experiments 11, 15
bromoides, reproduction, experiments in Santa Rita Mountains 11–12
seeding, experiments 15, 16
curtipendula, seeding, experiments 14
oligostachya, importance, origin and description 14
seeding, experiments 14
rothrockii, reproduction, experiments 11–12
seeding, experiments 14, 15, 16
vestita, seeding, experiments 14, 15
Bromus maximus, introduction, experiments 13
Brush, cause of unproductiveness 9
California, forage plants, experiments in introduction 13
Cattle, influence in spreading seed of mesquite 23
Clover, bur, introduction, experiments 13
Coronado National Forest, fencing of pastures 7–9
Crops, farm, arid regions, importance of thin seeding 11–12
Desert plants. *See* Plants, desert.
Eurodium cicutarium, introduction, experiments 12
Farm crops. *See* Crops, farm.
Feed, grasses, accumulation upon ground and appearance 17
production, influence of rainfall 20–21
uniformity and increase 19, 20
yield, conditions, etc 20–21
Fires, forest, arid regions, value in controlling shrubs 22
Flood waters. *See* Waters, flood.
Forage, growth in desert regions, appearance, habits, etc 17
Plant Investigations, Office, plants furnished for testing 12–13
plants. *See* Plants, forage.

Page.
Forage, yield, influence of distribution and quantity of moisture 20–21
of inclosed area, 1903–1908 19–21
Forest, Coronado National, fenced pastures 7–9
fires. *See* Fires, forest.
Golden-rod, rayless, danger of encroachment, remedies, etc 17–18
weed enemy of grasses in arid regions 17–18
Grama grasses. *See* Grasses, grama.
Grass, galleta, large growth upon swales due to flood waters 9
perennial, seedlings, production in fenced area 12
Grasses, annual and perennial, growth, comparison 15
inclosed area, increased growth 16–17
small value as ground covering 9
arid regions, most important 11–12
seedling plants, economic importance, etc 11–12
weed enemies 17–18
desert, power of seed production 11
grama, persistency, value, etc 10
seed, production in private pastures in 1908 10
growth, cause of increase 16–17
influence of altitude 9–10
large, caused by flood waters 9
native, seeding, experiments 14
perennial, ascendancy over weedy annuals 16
desert lands, influences controlling yield, etc 11–12
disappearance, cause 15–16
growth, conditions, etc 16
in arroyos 17
swales 17
increase 16–17
reproduction, experiments and results in Santa Rita Mountains 11–12
private pastures, comparison of growth for 1908 with previous years 10
reseeding, artificial, experiments 12–14
natural 11–12
See also Grasses, seeding.
root, disappearance, cause 15–16
seeding, thin, arid regions, importance 11–12
See also Grasses, reseeding.
seedlings, production, yield, etc 11–12
six weeks', increase of crop, 1908 10
summer, irrigation studies 17
Grazing, care in restocking arid land 13
system, land capacity 13–14
Ground, cover, accumulation, description, distribution, etc 9–10
effect of moisture 9–10
protection 9
See also Herbage, dead.
Gutierrezia, enemy of economic plants 18
Hay, area, description 10
Helvetia, Ariz., tributary region, production of grasses in 1908 10
Herbage, dead, surface covering, accumulation, disposition, etc 9–10
See also Ground, cover.

Page.
Herbage, yield of inclosed area 19–21
Horses, grazing, use of private pastures 10
influence in spreading seed of mesquite 23
Introduction to bulletin 7
Isocoma coronopifolia, enemy of arid-region grasses 17–18
Lands, desert, perennial grasses, influences controlling yield, etc 11–12
mesa, lower unirrigated, absence of perennials 17
overgrazed, protection to induce original productivity, time required, etc 13
treatment 13
range, reseeding, artificial, experiments 12–14
natural 11–12
restocking, natural 12
Leptochloa dubia, seeding, experiments 14, 15
Loco weeds. *See* Weed, loco.
Lupinus arizonicus, description, danger, etc 18–19
Machalranthera sp., growth, 1907 and 1908, comparison 14–15
Medicago denticulata, introduction, experiments 13
maximus, introduction, experiments 13
Mesa lands. *See* Lands, mesa.
Mesquite, spread, causes, damage, etc 21–23
influence of cattle and horses 23
value as forage plant 21
Moisture, distribution and quantity, influence on yield of forage 20–21
effect on ground cover 9–10
Oats, wild, introduction, experiments 13
Pasturage, carrying capacity, study 21
Pastures, fencing, in Coronado National Forest 7–9
increased carrying capacity 21
private, grasses, persistency and results in 1908 10
management 8–9
use for grazing by horses 10
sheep 10
Plantago fastigiata, production in 1901 15
Plants, desert, seed production and reseeding of land 10–11
forage, artificial reseeding, experiments 12–14
California, introduction, experiments 13
native and foreign, comparison 13
efforts to establish, etc 12–14
species, native and foreign, experiments and studies 12–14
Precipitation, distribution 9–10
Prosopis glandulosa, shrubby vegetation, spread, causes, etc 21–23
velutina, bean production 21
Protection, effect on ground cover 9
Rainfall, inclosed area, distribution 9–10
heaviest in 240-acre pasture 9–10
influence on feed production 20–21
record taken in 204-acre pasture 9
Range lands. *See* Lands, range.
open, seeding possibilities, discussion 14
stock, inclosed area in Arizona, history, early 7–8
since 1903 8–9

Page.
Regions, arid, grasses most important 11–12
seedling plants, economic importance, etc 11–12
weed enemies 17–18
shrubs, control, benefits of forest fires 22
thin seeding, importance 11–12
desert, forage, growth, appearance, habits, etc 17
vegetation, causes of various forms 22–23
Reseeding, grasses. *See* Grasses, reseeding.
Santa Rita Mountains, grasses, perennial, reproduction experiments 11–12
growth of Bouteloua oligostachya 14
Seasons, rainy, summer and winter, dates, rainfall, etc 19–21
Seed, failure, causes 14
foreign, results of planting 13
grama grasses, production in private pastures in 1908 10
planting, methods 13
production, desert plants 10–11
Seeding denuded areas, methods 14
grasses. *See* Grasses, seeding.
Seedlings, perennial grasses, production in fenced area 12
Sheep, grazing, use of private pastures 10
Shrubs, arid regions, control, benefits of forest fires 22
danger to mowing machines 21–22
increase, causes, dangers, etc 21–23
Six-weeks' grasses. *See* Grasses, six-weeks'.
Soil, surface covering. *See* Ground, cover.
Stock range. *See* Range, stock.
Summary of bulletin 24
Swales, ground cover, description 9
growth of perennial grasses 17
Tucolote, introduction, experiments 13
Vegetation, changes, permanent 15–17
temporary, studies and comparisons 14–15
desert regions, causes of various forms 22–23
grass varieties, comparison by years 15
native, husbanding, benefits and results 13–14
value, management, etc 13
private pastures, increase of growth in 1908 10
yield of inclosed area 19–21
Waters, flood, cause of large growth of grasses 9
effect on ground cover 9, 10
Weed, loco, damage to horse industry 17
occurrence, habits of growth, danger, etc 17–18
Weeds, varieties and importance in Arizona pasture 17–19

O

[Continued from page 2 of cover.]

No. 113. Tolerance of Various Plants for Salts in Alkali Soils. 1907. Price, 5 cents.
114. Sap-Rot and Other Diseases of the Red Gum. 1907. Price, 15 cents.
115. Disinfection of Sewage for Protection of Public Water Supplies. 1907. Price, 10 cents.
116. The Tuna as Food for Man. 1907. Price, 25 cents.
117. The Reseeding of Depleted Range and Native Pastures. 1907. Price, 10 cents.
118. Peruvian Alfalfa. 1907. Price, 10 cents.
119. The Mulberry and Other Silkworm Food Plants. 1907. Price, 10 cents.
120. Production of Easter Lily Bulbs in the United States. 1908. Price, 10 cents.
121. Miscellaneous Papers. 1908. Price, 15 cents.
122. Curly-Top, a Disease of Sugar Beets. 1908. Price, 15 cents.
123. The Decay of Oranges in Transit from California. 1908. Price, 20 cents.
124. The Prickly Pear as a Farm Crop. 1908. Price, 10 cents.
125. Dry-Land Olive Culture in Northern Africa. 1908. Price, 10 cents.
126. Nomenclature of the Pear. 1908. Price, 30 cents.
127. The Improvement of Mountain Meadows. 1908. Price, 10 cents.
128. Egyptian Cotton in the Southwestern United States. 1908. Price, 15 cents.
129. Barium, a Cause of the Loco-Weed Disease. 1908. Price, 10 cents.
130. Dry-Land Agriculture. 1908. Price, 10 cents.
131. Miscellaneous Papers. 1908. Price, 10 cents.
133. Peach Kernels, etc., as By-Products of the Fruit Industry. 1908. Price, 5 cents.
134. Influence of Soluble Salts upon Leaf Structure and Transpiration of Wheat, Oats, and Barley. 1908. Price, 5 cents.
135. Orchard Fruits in Virginia and the South Atlantic States. 1908. Price, 20 cents.
136. Methods and Causes of Evolution. 1908. Price, 10 cents.
137. Seeds and Plants Imported. Inventory No. 14. 1909. Price, 10 cents.
138. Production of Cigar-Wrapper Tobacco in Connecticut Valley. 1908. Price, 15 cents.
139. American Medicinal Barks. 1909. Price, 15 cents.
140. "Spineless" Prickly Pears. 1909. Price, 10 cents.
141. Miscellaneous Papers. 1909. Price, 10 cents.
142. Seeds and Plants Imported. Inventory No. 15. 1909. Price, 10 cents.
143. Principles and Practical Methods of Curing Tobacco. 1909. Price, 10 cents.
144. Apple Blotch, a Serious Disease of Southern Orchards. 1909. Price, 15 cents.
145. Vegetation Affected by Agriculture in Central America. 1909. Price, 15 cents.
146. The Superiority of Line Breeding over Narrow Breeding. 1909. Price, 10 cents.
147. Suppressed and Intensified Characters in Cotton Hybrids. 1909. Price, 5 cents.
148. Seeds and Plants Imported. Inventory No. 16. 1909. Price, 10 cents.
149. Diseases of Deciduous Forest Trees. 1909. Price, 15 cents.
150. Wild Alfalfas and Clovers of Siberia. 1909. Price, 10 cents.
151. Fruits Recommended for Cultivation. 1909. Price, 15 cents.
152. Loose Smuts of Barley and Wheat. 1909. Price, 15 cents.
153. Seeds and Plants Imported. Inventory No. 17. 1909. Price, 10 cents.
154. Farm Water Supplies of Minnesota. 1909. Price, 15 cents.
155. Control of Black-Rot of the Grape. 1909. Price, 15 cents.
156. A Study of Diversity in Egyptian Cotton. 1909. Price, 15 cents.
157. The Truckee-Carson Experiment Farm. 1909. Price, 10 cents.
158. The Root-Rot of Tobacco Caused by Thielavia Basicola. 1909. Price, 15 cents.
159. Local Adjustment of Cotton Varieties. 1909. Price, 10 cents.
160. Italian Lemons and Their By-Products. 1909. Price, 15 cents.
161. A New Type of Indian Corn from China. 1909. Price, 10 cents.
162. Seeds and Plants Imported. Inventory No. 18. 1909. Price, 10 cents.
163. Varieties of American Upland Cotton. 1910. Price, 25 cents.
164. Promising Root Crops for the South. 1910. Price, 10 cents.
165. Application of Principles of Heredity to Plant Breeding. 1910. Price, 10 cents.
166. The Mistletoe Pest in the Southwest. 1910. Price, 10 cents.
167. New Methods of Plant Breeding. 1910. Price, 20 cents.
168. Seeds and Plants Imported. Inventory No. 19. 1909. Price, 5 cents.
169. Variegated Alfalfa. 1910. Price, 10 cents.
170. Traction Plowing. 1910. Price, — cents.
171. Some Fungous Diseases of Economic Importance. [In press.]
172. Grape Investigations in Vinifera Regions. [In press.]
173. Seasonal Nitrification as Influenced by Crops and Tillage. [In press.]
174. The Control of Peach Brown-Rot and Scab. 1910. Price, — cents.
175. The History and Distribution of Sorghum. 1910. Price, — cents.
176. Seeds and Plants Imported. Inventory No. 20. [In press.]